



Annex 1: 2022 UK greenhouse gas emissions, final figures with energy supply on an end user basis and uncertainty estimates

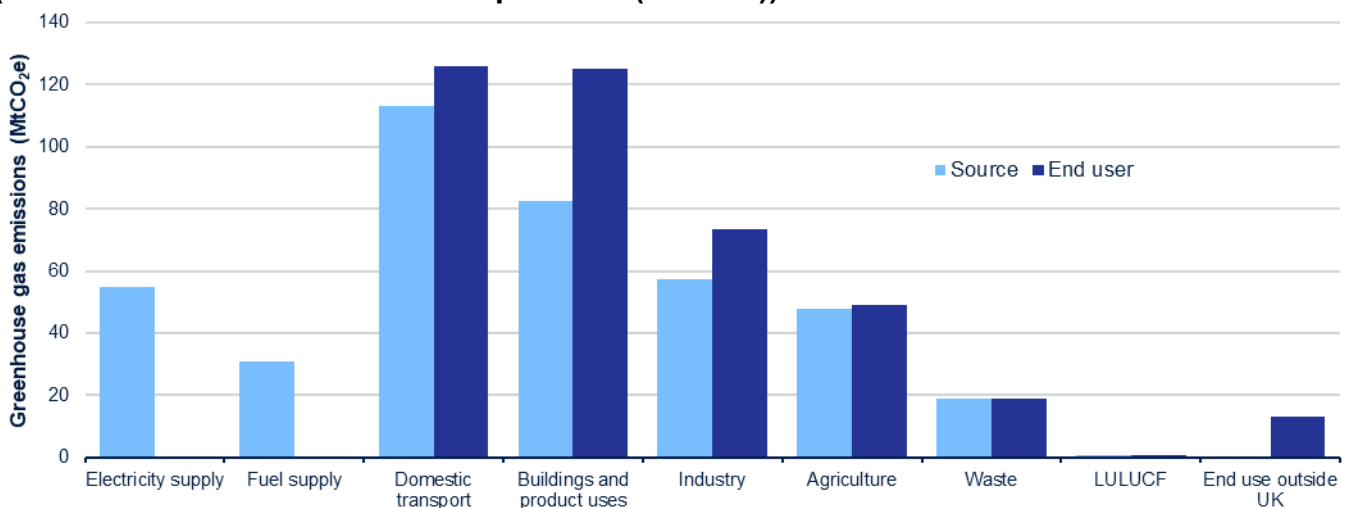
28 March 2024

National Statistics

This publication is an extension of the UK territorial greenhouse gas emission estimates by source for 1990-2022 published in February 2024. It provides the latest estimates of 1990-2022 territorial greenhouse gas emissions with energy supply emissions presented on an end user basis rather than a by source basis. This means that emissions from electricity and fuel supply, e.g. from power stations and refineries, have been reallocated to other sectors based on where the “end-use” of the energy occurred. The total emissions presented here are consistent with the data published in February by source sector. Uncertainty estimates for UK territorial greenhouse gas emissions are also presented by gas and by source sector. Figures are presented in carbon dioxide equivalent units throughout this statistical release.

- It is estimated that 31% of net greenhouse gas emissions in the UK in 2022 were from domestic transport and a further 31% from buildings and product uses, making them the largest sectors when energy supply is on an end user basis. 18% of emissions were from industry and 12% from agriculture. The rest were attributable to the waste and the land use, land use change and forestry (LULUCF) sectors, or had their end use outside the UK.

Figure 1: Greenhouse gas emissions by source sectors and end user sectors, UK 2022 (million tonnes carbon dioxide equivalent (MtCO₂e))



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

- Uncertainty in UK greenhouse gas emissions estimates is around 3%, based on uncertainty analysis of the 2022 emissions estimates which were published in February 2024. The uncertainty of UK greenhouse gas emissions estimates varies considerably by gas and sector. Carbon dioxide estimates have the least uncertainty associated with them while nitrogen trifluoride and perfluorocarbons estimates are the most uncertain. At sector level, LULUCF emissions estimates have the highest uncertainty, followed by waste, fuel supply and agriculture.

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Introduction

This Annex contains final estimates of 1990 to 2022 UK territorial greenhouse gas emissions with energy supply on an end user basis, as well as uncertainty estimates for 2022 emissions by source sector and gas. These are a follow up to, and are consistent with, the final estimates of 1990 to 2022 emissions by source sector which were published on 6th February 2024.

Emissions by end user and the uncertainty estimates have now been incorporated as updates into the data tables published alongside the [Final UK Greenhouse Gas Emissions Statistics](#). Tables 7.1 to 7.6 present emissions by end user category overall and for each gas, and are included in a separate file from the other tables published as part of this publication. Uncertainty analysis for 2022 emissions by gas and by sector are shown in tables 4.1 and 4.2 respectively. A dataset of the end user estimates has also been included in the publication.

The geographic coverage of emissions by end user in this report is UK only. In these statistics, emissions are allocated into Territorial Emissions Statistics (TES)¹ sectors as follows:

- Electricity supply
- Fuel supply
- Domestic transport
- Buildings and product uses
- Industry
- Agriculture
- Waste
- Land use, land use change, and forestry (LULUCF)

When emissions are reported by source, emissions are attributed to the sector that emits them directly. In the end user breakdown, emissions related to energy supply are reallocated to the sectors where the “end-use” of the energy occurred. The emissions reallocated include the whole of the electricity supply and fuel supply source sectors, along with a small number of sources in the industry sector (in particular autogeneration of electricity and coke production). Some emissions are also allocated to an “end use outside UK” category. This is for emissions within the UK from the production of fuels (e.g. from a refinery or coal mine) or electricity generation, which are subsequently exported or sent to bunkers for use outside the UK.

These estimates make it possible to see the full emissions impact within the UK of a particular end-use sector or sub-sector, although it should be noted that emissions that occur outside the UK from the supply of energy used in the UK are excluded, such as where fuels or electricity have been imported. This also enables the emissions to be further geographically disaggregated. Devolved administration and local authority emissions estimates, based on the end user breakdown, will be published in June 2024.

The uncertainty estimates are used to prioritise further research into improving emissions estimates, and more generally give users an indication of the robustness of the greenhouse gas emissions estimates for different sectors. The geographic coverage of the uncertainty estimates includes the UK, Crown Dependencies and Overseas Territories.

¹ The TES sectors were introduced this year to replace the National Communication (NC) sectors used previously, see the [Final UK Greenhouse Gas Emissions Statistics](#) statistical release for more details about this change.

1990-2022 total greenhouse gas emissions with energy supply on an end user basis

In the [data tables](#) accompanying this publication, table 7.1 shows overall UK greenhouse gas emissions since 1990 by end user sector and source, while tables 7.2 to 7.5 show this breakdown for each individual gas.

These results are based on and consistent with the breakdown by gas and sector of 2022 emissions by source which was published on 6th February 2024. Total greenhouse gas emissions in the UK in 2022 were 406.2 million tonnes carbon dioxide equivalent (MtCO_{2e}).

The end user breakdown reallocates emissions related to energy supply to where the “end-use” of that energy occurred. This means that emissions from the supply of electricity and fuels are reallocated to other sectors. For example, emissions occurring at power stations in generating electricity are reallocated to where the electricity is consumed. It should be noted that the results shown by this breakdown are based on a number of assumptions, and we would therefore expect them to be subject to greater uncertainty than the breakdown of emissions by source.

When looked at by end user sector, 31% of greenhouse gas emissions in the UK in 2022 were from domestic transport, 31% from buildings and product uses, 18% from industry and 12% from agriculture. The remainder were attributable to the waste and the land use, land use change and forestry (LULUCF) sectors, or had their end use outside the UK. No energy supply emissions are reallocated to the waste or LULUCF sectors and hence they are assumed to be equal to the by source emissions.

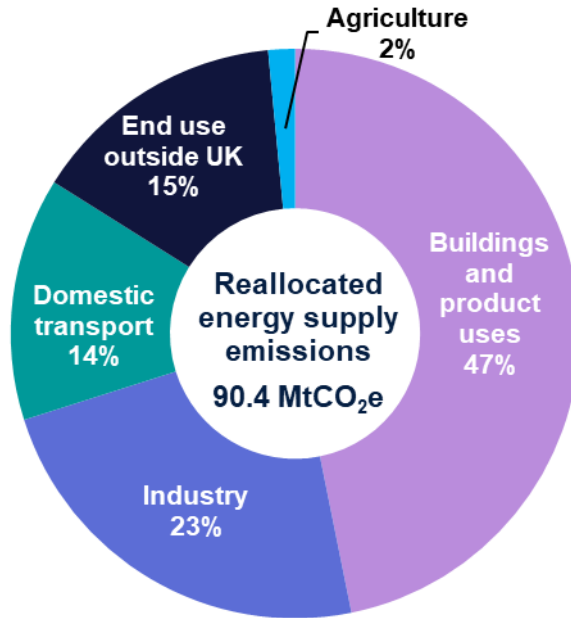
Figure 2: Proportion of net greenhouse gas emissions in each end user sector, UK 2022



Source: Table 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables
 Note: The percentages may not sum to 100% due to rounding.

Nearly half (47%) of energy supply emissions are reallocated to the buildings and product uses sector, with the industry sector accounting for 23% of reallocated emissions and domestic transport 14%, as shown in figure 3 below.

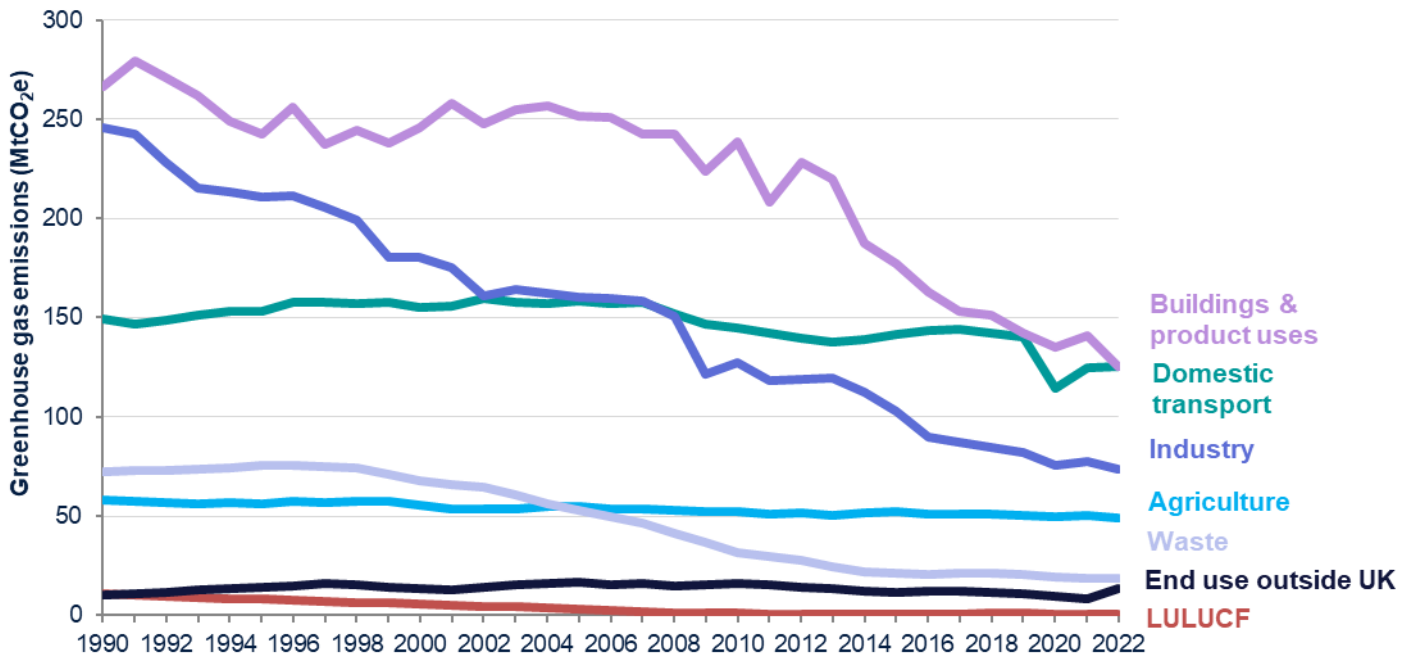
Figure 3: Breakdown of greenhouse gas emissions reallocated from the electricity supply and fuel supply sectors to the end user sectors, UK 2022



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

The buildings and product use sector has been the sector with the highest emissions on an end user basis in all years throughout the time series since 1990 except 2022, when the domestic transport sector was slightly higher.

Figure 4: Greenhouse gas emissions by end user sector, UK 1990-2022



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

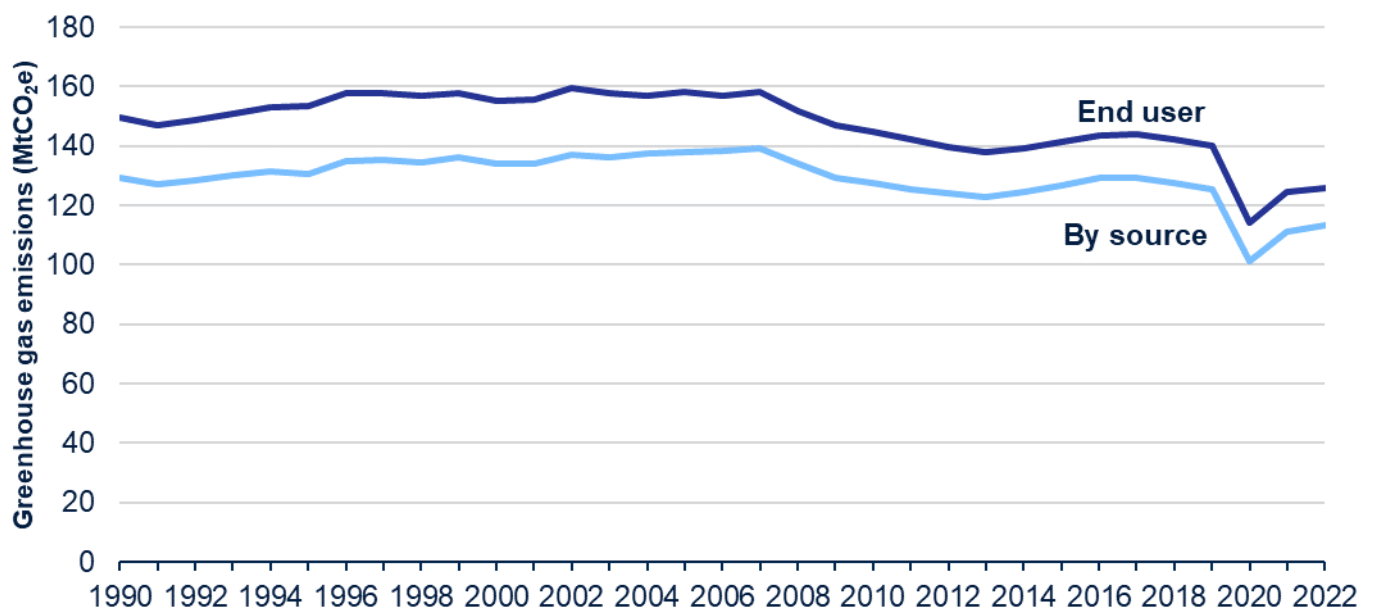
Details of changes over time for each sector are set out in the following sections of this statistical release. The commentary in these sections focuses on the differences between the end user and by source breakdowns. Further information on trends of emissions by source sector can be found in the statistics release of the [Final UK Greenhouse Gas Emissions Statistics](#).

Domestic transport

The domestic transport sector was responsible for around 31% of UK greenhouse gas end user emissions in 2022, almost entirely through carbon dioxide emissions. It was the highest emitting sector on an end user basis (125.7 MtCO_{2e}), very closely followed by buildings and product uses (125.1 MtCO_{2e}). Emissions of carbon dioxide are closely related to the amount of fuel used, whilst nitrous oxide and methane emissions are influenced more by the vehicle type and age. The main source of emissions from this sector is the use of petrol and diesel in road transport.

End user emissions from domestic transport are between 12 and 23 MtCO_{2e} higher each year than emissions by source across the time series, so follow a very similar trend. Between 1990 and 2019 there was relatively little overall change in the level of greenhouse gas emissions from the sector, with rising road traffic balancing out improvements in fuel efficiencies, but in 2020 there was a large fall of 18% in domestic transport emissions on an end user basis due to the reduction in travel throughout much of the year due to the COVID-19 pandemic. Emissions increased by 10% over the subsequent two years as COVID-19 restrictions were eased and people were able to travel more freely, but were still 10% lower in 2022 than they were in 2019, the last full year before the pandemic.

Figure 5: Greenhouse gas end user emissions from domestic transport, UK 1990-2022 (MtCO_{2e})



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

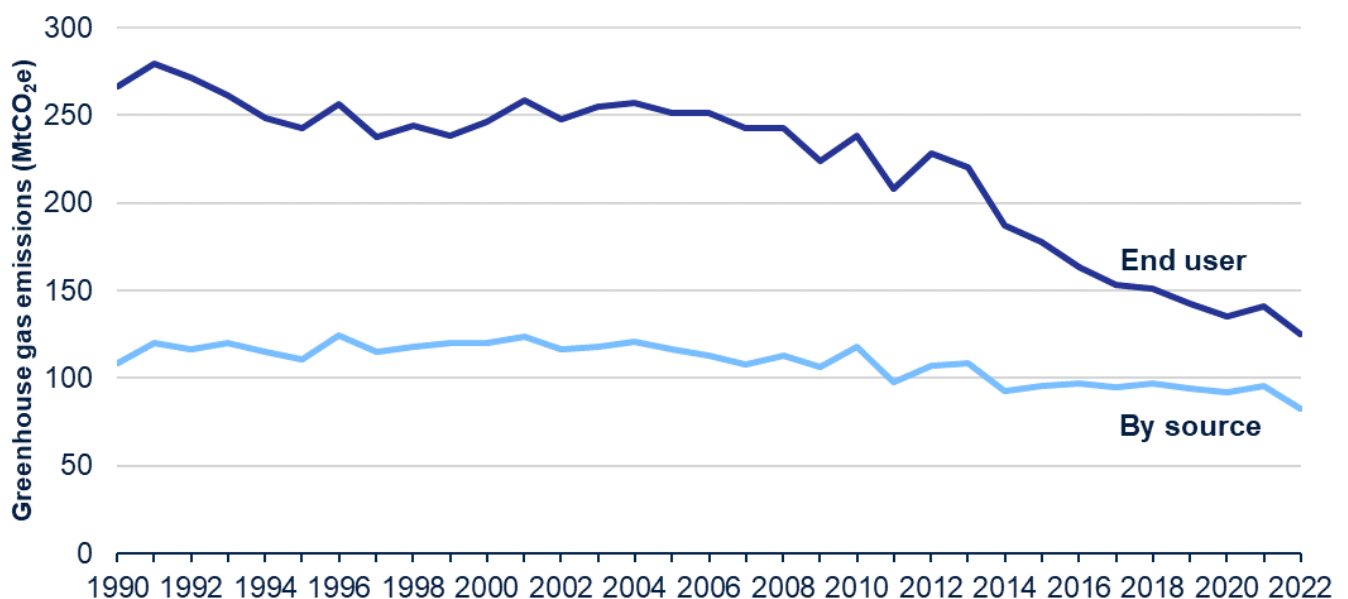
Buildings and product uses

The buildings and product uses sector was responsible for 31% of UK greenhouse gas end user emissions in 2022. This is the first year since the start of the time series in 1990 that it was not the sector with the highest greenhouse gas emissions when energy supply is presented on an end user basis, as emissions from domestic transport were higher by a narrow margin, as noted in the previous section. Carbon dioxide was the most prominent gas. Emissions from this sector primarily come from fuel combustion and electricity use in buildings. Other sources include emissions that directly arise from the use of products such as refrigeration & air conditioning, garden machinery, anaesthetics, metered dose inhalers and aerosols. Residential buildings, including electricity use, were responsible for 64% of emissions in this sector in 2022, and 20% of all UK territorial emissions.

There was an 11% (16.0 MtCO_{2e}) decrease in end user emissions from the buildings and product uses sector between 2021 and 2022. This is likely to largely be related to warmer temperatures in 2022 resulting in less energy being used to heat buildings, and it may have also been affected by higher energy prices, particularly towards the end of the year. This decrease in 2022 is similar to the decrease of 13% (12.7 MtCO_{2e}) seen in emissions by source from this sector over this period.

Between 1990 and 2022, there has been considerable variation in greenhouse gas end user emissions from year to year in the buildings and product uses sector. Both the end user and by source emissions from this sector are heavily influenced by external temperatures. End user emissions from this sector have fallen by 53% since 1990 and have seen a bigger overall decrease than by source emissions, particularly since 2012. They were 45% lower in 2021 than in 2012, compared to a 23% fall in emissions by source over this period. This is due to the large reduction in emissions from power supply as a result of a shift away from the use of coal in electricity generation, resulting in a lower level of emissions being reallocated to this sector from the electricity supply sector.

Figure 6: Greenhouse gas end user emissions from buildings and product uses, UK 1990-2022 (MtCO_{2e})



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

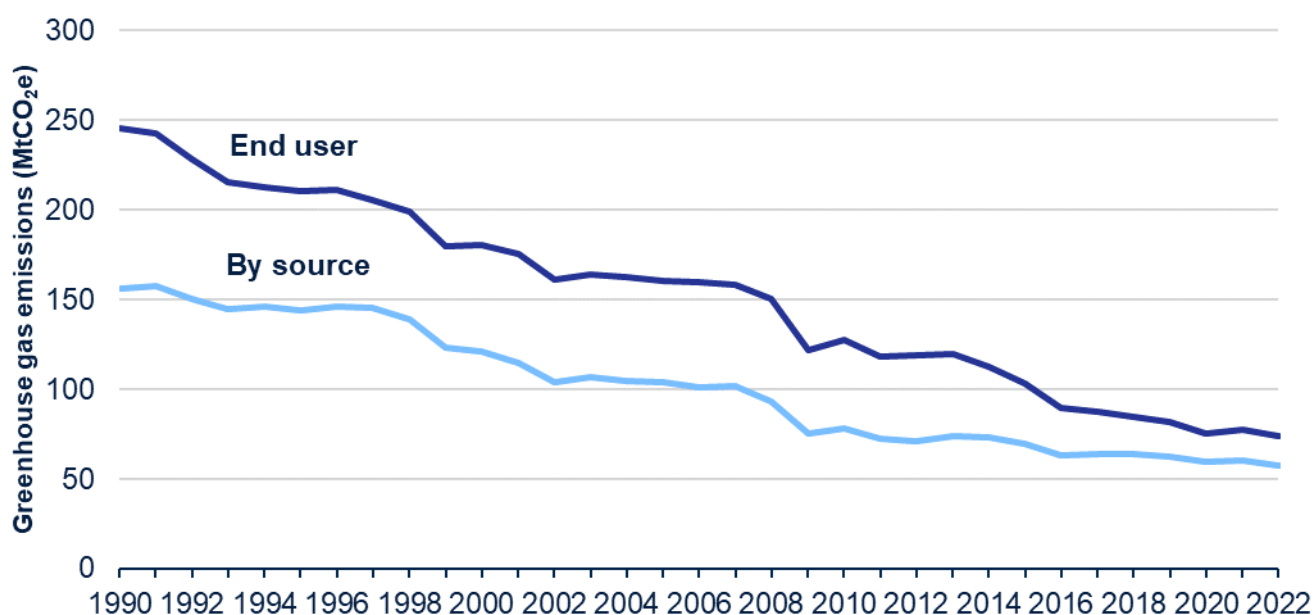
Industry

The industry sector was responsible for 18% of UK greenhouse gas end user emissions in 2022. This sector includes emissions from fuel combustion and electricity use at industrial sites and from industrial machinery, emissions resulting from industrial processes and emissions of fluorinated gases from industrial uses such as in refrigeration systems.

Between 1990 and 2022 there was a general downward trend in greenhouse gas end user emissions from industry, resulting in an overall decrease of 70%. Emissions decreased by 5% (3.8 MtCO_{2e}) between 2021 and 2022. This decrease is similar to the decrease of 5% (3.2 MtCO_{2e}) seen in emissions by source from this sector over this period, largely because of a reduction in emissions from industrial combustion and from iron and steel production.

Overall, end user emissions have fallen more quickly since 1990 than emissions by source, particularly since 2012. They were 38% lower in 2022 than in 2012, compared to a 20% fall in emissions by source over this period. This is due to the large reduction in emissions from power supply as a result of a shift away from the use of coal in electricity generation, resulting in a lower level of emissions being reallocated to this sector from the electricity supply sector.

Figure 7: Greenhouse gas end user emissions from industry, UK, 1990-2022 (MtCO_{2e})



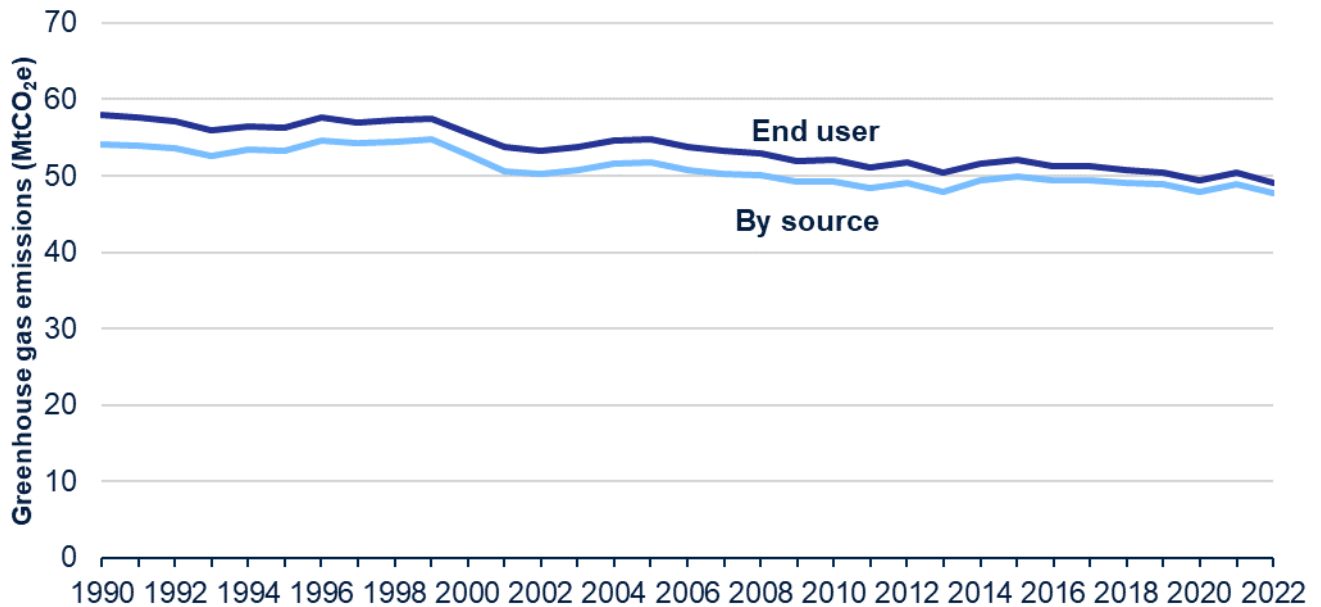
Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

Agriculture

The agriculture sector was responsible for 12% of UK greenhouse gas end user emissions in 2022. Emissions of methane (57%) and nitrous oxide (26%) dominate this sector. End user and by source emissions are very similar for this sector as only a small proportion of emissions are from energy use. The most significant sources are emissions of methane due to enteric fermentation from livestock, particularly cattle, and nitrous oxide emissions related to the use of fertilisers on agricultural soils.

End user emissions follow a similar trend to by source emissions. Emissions have decreased by 15% since 1990 largely due to a fall in animal numbers over the period, together with a decrease in synthetic fertiliser use. Between 2021 and 2022 there was a 3% decrease in emissions from the agriculture sector largely due to a reduction in fertiliser use and a decrease in emissions from agricultural machinery.

Figure 8: Greenhouse gas end user emissions from agriculture, UK 1990-2022 (MtCO₂e)



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

Waste and Land Use, Land Use Change and Forestry (LULUCF)

For the waste and LULUCF sectors, emissions measured by end user are the same as those measured by source, since no emissions from energy supply are reallocated to these sectors.

Emissions from energy supply with end use outside the UK

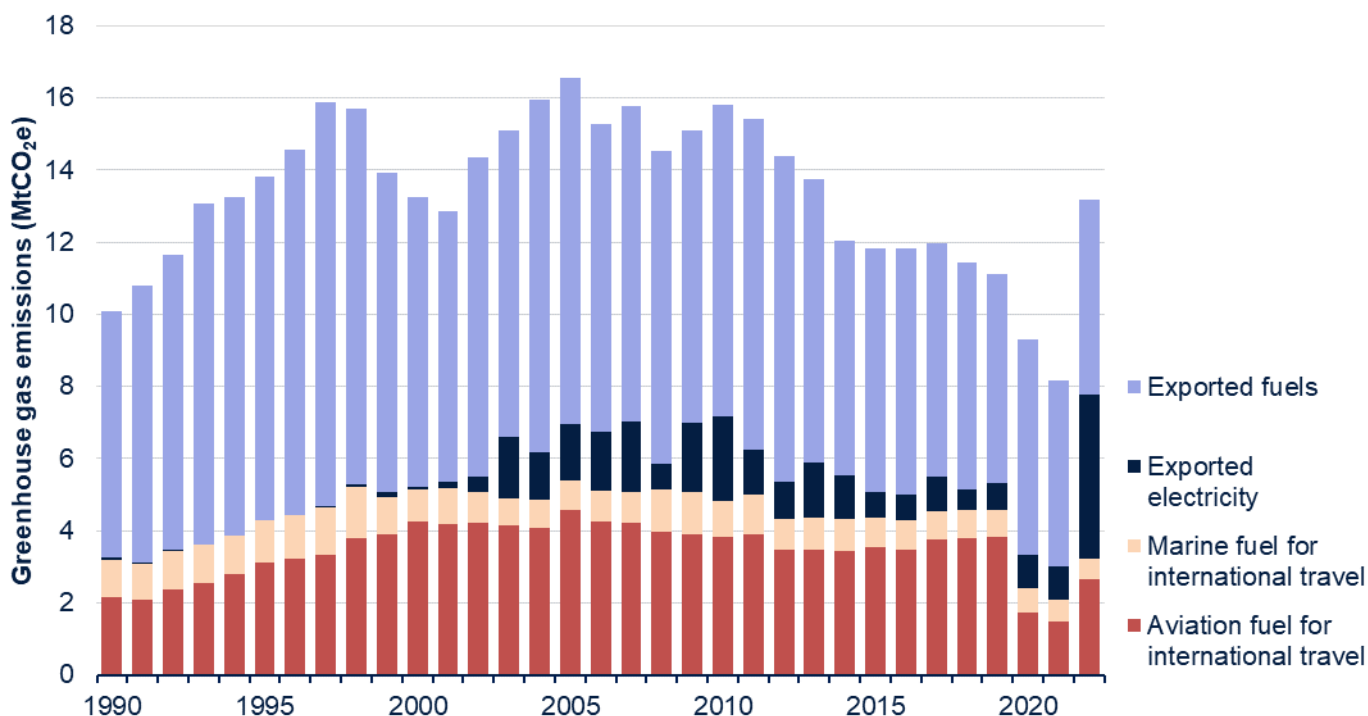
The end use outside the UK sector represents emissions associated with the production of fuels within the UK (for example, from a refinery or a coal mine) which are subsequently exported or sent to bunkers for use outside the UK. It also includes emissions from generating electricity in the UK that is exported. Since this energy is ultimately used for activities which occur outside the UK it would not be appropriate to allocate the emissions from their production to any of the other end user sectors, so they are reported under a separate, additional sector.

Around 3% of UK territorial greenhouse gas emissions in 2022 were from energy supply that had its end user outside the UK, with carbon dioxide representing the majority of these emissions.

Emissions from the end use outside the UK sector increased during most of the 1990s, largely driven by changes in throughput² at refineries, which fed through to increased exports rather than increased deliveries to the domestic market. Since then, the overall trend has varied, with emissions having fallen in recent years compared to the peaks in the mid to late 2000s.

After falls in 2020 and 2021 largely due to reduced use of aviation fuel during the COVID-19 pandemic, emissions from energy supply with its end use outside the UK increased by 61% in 2022, to the highest level since 2013. This was mostly due to a large rise in electricity exported, as demand from Europe saw the UK switch to being a net exporter of electricity for the first time in over 40 years. There was also a partial recovery in international air travel following the easing of COVID-19 pandemic restrictions, resulting in higher emissions from supplying aviation fuel.

Figure 9: UK greenhouse gas emissions from energy supply with end use outside the UK, 1990-2022 (MtCO₂e)



Source: Table 7.1 Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

² The capacity for refining crude oil over a given period of time

Uncertainties around the 2022 estimates

In the [data tables](#) accompanying this publication, table 4.1 shows the uncertainty in the 2022 UK greenhouse gas emissions estimates by gas and table 4.2 shows it by source sector.

This section sets out the uncertainty ranges associated with the final 2022 emissions estimates by source, which were published on 6th February 2024. The geographic coverage of the uncertainty estimates includes the UK, its Crown Dependencies and those Overseas Territories that are included in the UK's reporting to the United Nations Framework Convention on Climate Change (i.e. the Cayman Islands, Bermuda, the Falkland Islands and Gibraltar). Uncertainties are not calculated for different geographical coverages, but uncertainty estimates for the UK only would be expected to be very similar.

Estimates of uncertainty are produced each year, broken down by sector (on a source basis) and gas. The emissions estimates are compiled such that uncertainty is reduced as much as possible, meaning that estimates should not be consistently more or less than the actual totals. Estimates of uncertainty allow users to see how reliable the emissions estimates are and give them an idea of what we do and do not know. The uncertainties are expressed as a 95% confidence interval. This means that in the uncertainty model 95% of the simulated values fell between the intervals shown. They are expressed as a single percentage value, which is calculated as $0.5 \cdot R/E$ where R is the difference between the 2.5 and 97.5 percentiles and E is the mean.

The uncertainty analysis takes into account a number of different known sources of uncertainty associated with emissions factors and activity data, for example, the statistical difference³ between energy supply and demand reported in the [Digest of UK Energy Statistics](#). The different sources of uncertainty are then entered into a model using specialist software which produces uncertainty estimates by running the model a large number of times.

The uncertainty estimates vary a lot between different sectors and gases. Among the different greenhouse gases, carbon dioxide estimates have the lowest uncertainty associated with them while nitrogen trifluoride and perfluorocarbons estimates are the most uncertain. At sector level, the land use, land use change and forestry (LULUCF), waste, fuel supply and agriculture sectors are the most uncertain; as shown in figure 12.

The overall uncertainty around total greenhouse gas emissions for 2022 is estimated to be around 3%. There is an ongoing programme to reduce this uncertainty and the uncertainty estimates help guide decisions on improvements that are carried out for the emissions estimates. Further details can be found in the UK's national inventory submission to the United Nations Framework Convention on Climate Change (UNFCCC) which is due to be published later in 2024⁴.

The uncertainty in the trend in emissions reductions between 1990 and 2022, expressed as a 95% confidence interval, is estimated to be a percentage reduction of between 47% and 53%,

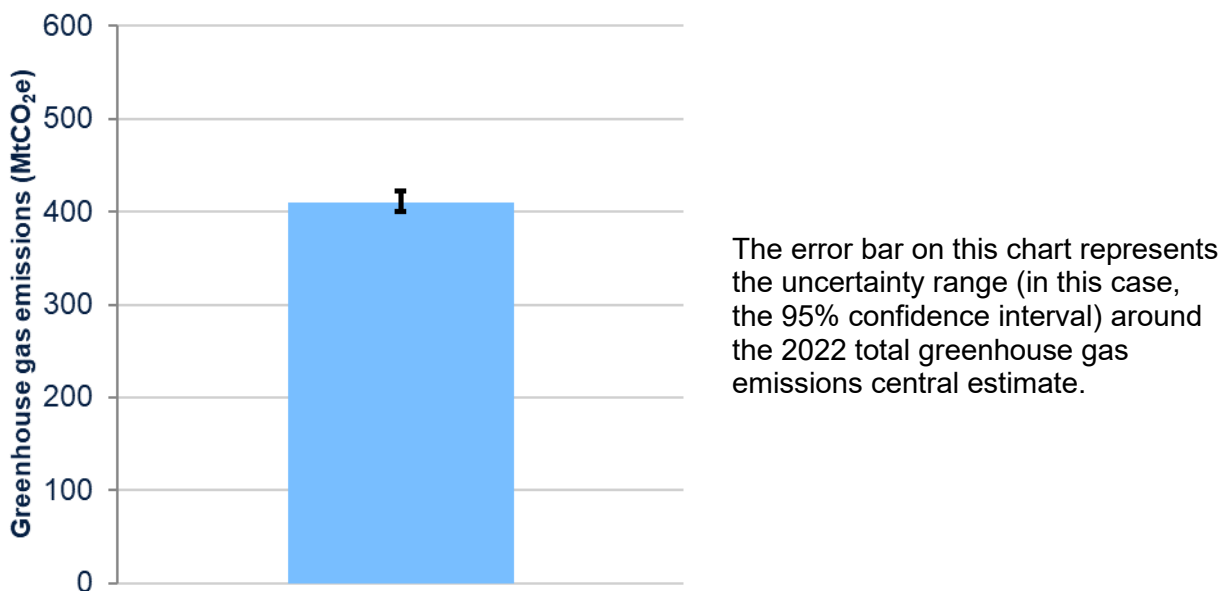
³ Statistical difference is explained on page 5 of the Energy Balance: Methodology note: <https://www.gov.uk/government/publications/energy-balance-methodology-note>

⁴ Previous UK National Inventory Report: https://naei.beis.gov.uk/reports/reports?report_id=1108

with a central estimate of a 50% reduction in emissions from 1990 to 2022. Note that this is the central estimate from the uncertainty model and may differ slightly from the actual emissions estimates presented elsewhere.

Figure 10: Illustration of uncertainty in estimates of UK greenhouse gas emissions

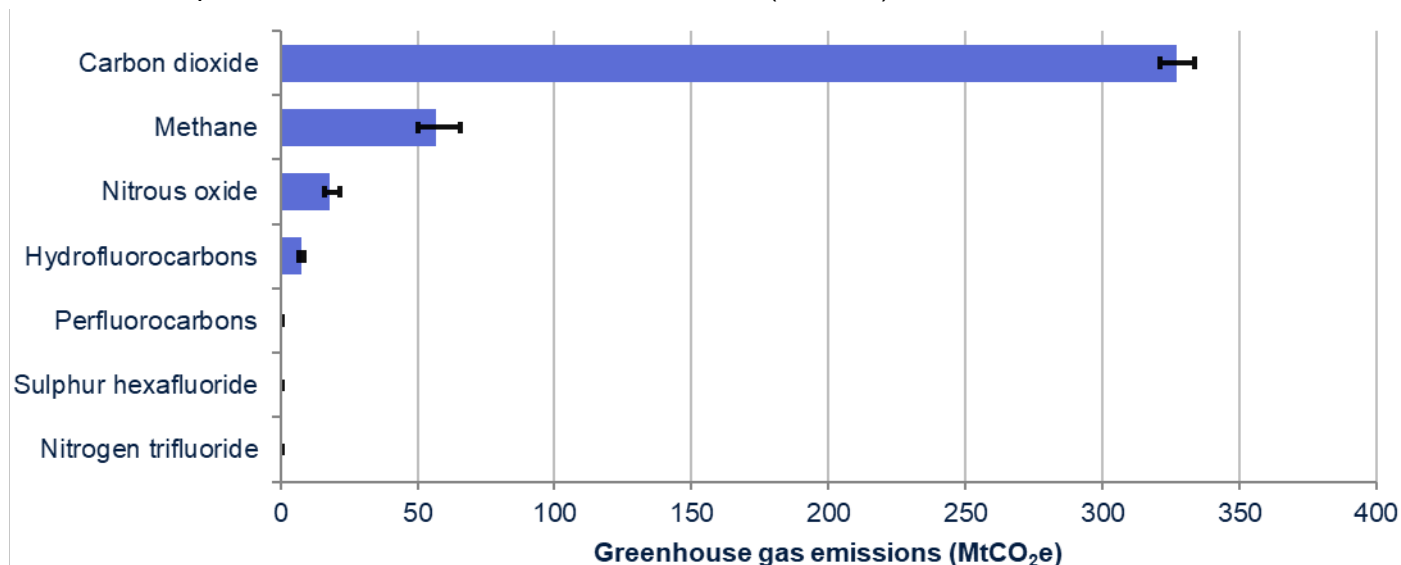
UK, Crown Dependencies and Overseas Territories, 2022 (MtCO₂e)



Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

Figure 11: Illustration of uncertainty in estimates of UK greenhouse gas emissions by gas

UK, Crown Dependencies and Overseas Territories, 2022 (MtCO₂e)

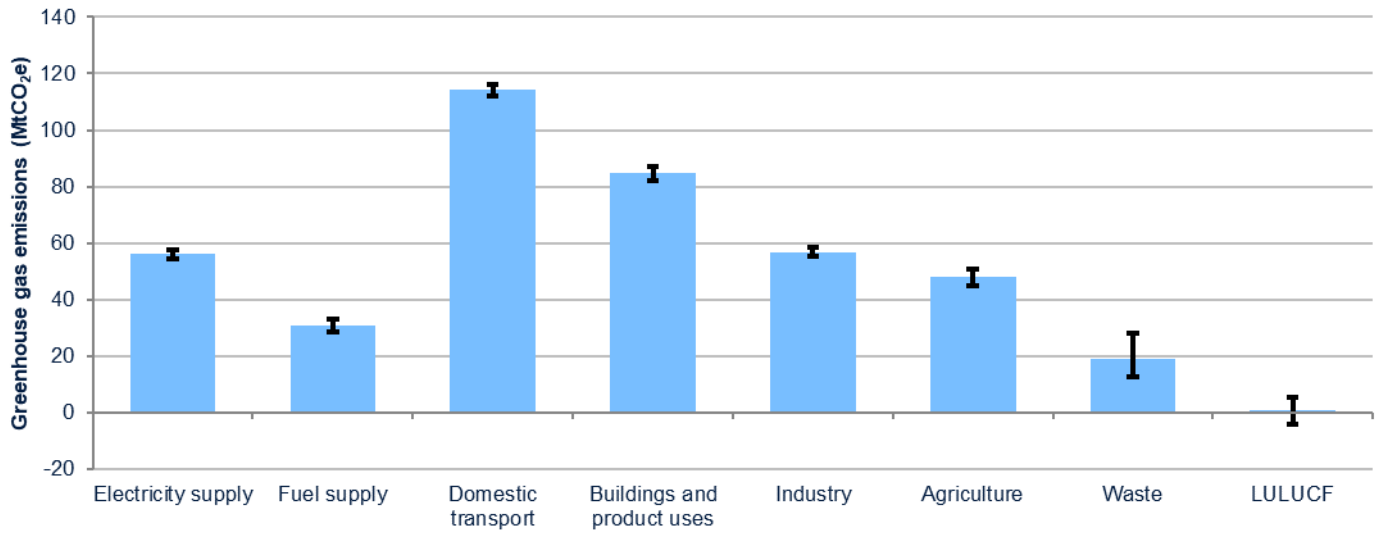


Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

Note: The error bars on the chart represent the uncertainty range (in this case, the 95% confidence interval) around the 2022 total greenhouse gas emissions central estimates for each gas.

Figure 12: Illustration of uncertainty in estimates of UK greenhouse gas emissions by source sector

UK, Crown Dependencies and Overseas Territories, 2022 (MtCO₂e)



Source: Table 4.2, Final UK greenhouse gas emissions national statistics 1990-2022 Excel data tables

Note: The error bars on the chart represent the uncertainty range (in this case, the 95% confidence interval) around the 2022 total greenhouse gas emissions central estimates for each sector.

Technical information

Methodology

The approach we use to estimate end user emissions is summarised in the three steps below:

1. Emissions are calculated for each sector for each fuel.
2. Emissions from fuel and electricity producers are then distributed to those sectors that use the fuel according to the energy content of the fuel they use (these sectors can include other fuel and electricity producers). This distribution is based on inventory fuel consumption data and DUKES electricity consumption data.
3. This distribution will have allocated most emissions to end users but some to fuel and electricity producers. Therefore, the process is repeated a number of times until only a negligible amount of emissions are still allocated to fuel and electricity producers, and the rest to end users.

Further information about the methodology used in the end user estimates is included in the inventory submission that the UK makes to the UNFCCC each year. This is shown in Annex 9 of the [most recent inventory report](#) covering 1990-2021 greenhouse gas emissions. The report covering 1990-2022 emissions will be published later this year.

Revisions to the estimates of end user emissions

It should be noted that the historical time series of emissions by end user is revised each year to reflect any revisions made to either the estimates of emissions by source or the other energy consumption data used in the end user emissions calculation. In this publication, this has resulted in revisions to end user emissions figures for all years up to and including 2021. Further details of these revisions can be found in the main [Final UK Greenhouse Gas Emissions Statistics report](#), which covered 2022 UK greenhouse gas emissions by source.

Embedded emissions

These territorial end user emissions estimates do not take account of the emissions “embedded” within the manufactured goods and services which the UK imports, only energy supply emissions that occur within the UK get reallocated to end users. Embedded emissions are instead captured in what is referred to as the UK’s “carbon footprint”. This calculation of emissions on a “consumption” basis, reporting on emissions embedded in goods and services across international borders, is considerably more challenging. Statistics on [the UK’s carbon footprint](#) are available from the Department for Environment, Food and Rural Affairs (Defra).

Further information

Future updates to greenhouse gas emissions estimates

On Thursday 27 June 2024 the Department for Energy Security and Net Zero will publish estimates of 1990-2022 UK territorial emissions by Standard Industrial Classification (SIC), to supplement the sector breakdown included in this publication.

On Thursday 27 June 2024 the Department for Energy Security and Net Zero will also publish estimates of greenhouse gas emissions by local authority for 2022.

In February 2025 final 1990-2023 UK greenhouse gas emissions estimates will be published by source sector.

In March 2025 the 1990-2023 UK emissions estimates will be updated to include estimates by end user and uncertainty estimates, and provisional 2024 greenhouse gas emissions estimates will be published.

Contact

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